R E P O R T R E S U M E S

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AN EIGHT WEEK SEMINAR IN AN INTRODUCTION TO NUMERICAL CONTROL ON TWO- AND THREE-AXIS MACHINE TOOLS (FOR VOCATIONAL AND TECHNICAL MACHINE TOOL INSTRUCTORS. FINAL REPORT). etc.

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THIRTY-THREE MACHINE SHOP INSTRUCTORS FROM 17 STATES PARTICIPATED IN AN 8-WEEK SEMINAR TO DEVELOP THE SKILLS AND KNOWLEDGE ESSENTIAL FOR TEACHING THE OPERATION OF NUMERICALLY CONTROLLED MACHINE TOOLS. THE SEMINAR WAS GIVEN FROM JUNE 20 TO AUGUST 12, 1966, WITH COLLEGE CREDIT AVAILABLE THROUGH STOUT STATE UNIVERSITY. THE PARTICIPANTS COMPLETED AN EVALUATION FORM AT THE END OF THE SEMINAR, AND A FOLLOWUP STUDY WAS MADE AFTER 1 YEAR. REPETITION OF ELEMENTS BY RESOURCE PERSONS AND INSTRUCTORS WAS ONE WEAKNESS INDICATED BY THE PARTICIPANTS. RESULTS OF 26 FOLLOWUP RESPONSES INDICATED THAT MOST INSTRUCTORS WORKED IN SCHOOLS WHICH HAD SPENT LESS THAN $40,000 ON EQUIPMENT, THAT MOST WERE INVOLVED IN TEACHING IN THE NUMERICAL CONTROL CURRICULUM, AND THAT ONLY FIVE WERE CLOSE TO EXTENSIVE USERS OF NUMERICALLY CONTROLLED EQUIPMENT. A QUESTIONNAIRE TO STATE DIRECTORS OF 16 STATES INDICATED THAT 16 NUMERICAL CONTROL PROGRAMS WERE OFFERED IN 1965-66, 47 WERE BEING OFFERED IN 1966-67, AND 75 WERE PLANNED FOR THE FOLLOWING YEAR. A LACK OF TEACHERS AND THE COST OF EQUIPMENT WERE IDENTIFIED AS THE MAJOR REASONS FOR NOT OFFERING MORE COURSES. IT WAS CONCLUDED THAT THE SEMINAR WAS WELL ACCEPTED, THE QUALITY OF INSTRUCTION WAS GOOD, THE OBJECTIVES WERE ACHIEVED, AND CONSIDERATIONS SHOULD BE GIVEN TO HAVING OTHER SEMINARS OF THIS TYPE. EVALUATION INSTRUMENTS AND A SUGGESTED CURRICULUM OUTLINE ARE INCLUDED. (EM)

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FINAL REPORT
Project No. 6-2332 -08
Grant No. OEG-3-6-062332-0720

An Eight-Week Seminar in An Introduction to Numerical Control on Two- and Three-Axis Machine Tools for Vocational and Technical Machine Tool Instructors

December 1967

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OFFICE OF EDUCATION

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An Eight Week Seminar in an Introduction to Numerical Control on Two- and Three- Axis Machine Tools for Vocational and Technical Machine Tool Instructors.

Project No. 6-2332
Grant No. OEG-3-6-062332-0720

Milton Boldt
Harry Pokorny

December, 1967

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Milwaukee Vocational Technical and Adult Schools

Milwaukee, Wisconsin

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INTRODUCTION

Numerical control machine tools have become an important segment of the metal working industry. It has been stated on many occasions by numerous people that numerical control is revolutionizing the metal working industry and its impact is on a par with the Industrial Revolution.

The vocational and technical schools are not in tune with this revolution. In fact, they are many years behind. In 1960, numerical control machine tools made up 6% of the total machine tools built, dollar-wise. It has been predicted that in 1966 it will be 20%. It is expected that 80% of metal working will be done by NC machines by 1980. With the rapid growth of this new type of production tool, it is obvious that a shortage of skilled workers in this area would exist. It also follows that our vocational and technical schools should train people to fit into this new field. However, few schools attempted to enter this training area because of the lack of skilled teachers and a lack of funds.

To help eliminate the lack of trained teachers, an eight-week seminar was conducted during the summer of 1966 at the Milwaukee Vocational Technical and Adult Schools under the auspices of the U.S. Office of Education and the Wisconsin Board of Vocational, Technical and Adult Education.

The purpose of this seminar was to assist in developing the skills and knowledge essential for teaching the operation of numerically controlled machine tools in the vocational and technical schools under Federally-supported Vocational and Technical Education Acts.

The objectives were:

1. To train instructors of the machine tool and related areas of training in the basic elements of numerical control technology.

2. To assist in the dissemination of knowledge and skills essential to the instruction of numerical control machine tool operation on a national level.

3. To aid these instructors in organization and development of instructional material.

4. To prepare these instructors for the organization and development of local instructor training institutes.

The specific objective of this seminar was to take machine tool trade instructors from various areas of the country where the need for this training is greatest, and train them in the elements of numerical control. It is expected that they, in turn, will be able to conduct instructor-training sessions for the local area, thereby making introductory numerical control instructor-training available on a nationwide basis in a minimum of time.

This seminar is expected to be the beginning of a pyramid of seminars all over the country, ultimately resulting in making vocational and technical education schools the basic training area for numerical control programmers, machine operators, and maintenance workers.

METHOD

The director of the Milwaukee Vocational Technical and Adult Schools, Dr. George Parkinson, appointed eight men from the school staff to form a committee chaired by Mr. Arthur Carlson to prepare a proposal for this seminar. (See Appendix A-1.) The committee met with resource personnel from the Numerical Control industry in the Milwaukee Area, and with staff members of the Wisconsin Board of Vocational, Technical and Adult Education and of the Madison Vocational, Technical and Adult School. The committee members also did extensive research in current metalworking publications to find trends in numerical control education.

The committee then met and established a formal purpose for the seminar and outlined the specific objectives to be achieved. It was at this time that criteria were established for the selection of participants. The committee was then broken up into three groups. One group was to work on the program of instruction; a second on the procuring of numerical control machine tools and peripheral equipment; and the third on the budget proposal.

The group working on the instructional program, after careful examination of the information gathered from the resource people and the publications research, defined the areas of instruction. The length, in hours, of each area of instruction was decided upon after a careful analysis of what was essential in each area and the estimated class time it would take for the students to learn these essentials. In establishing this breakdown of class hours, the group accomplished two other tasks at the same time. They found that eight weeks would be necessary to do a good job of instructing and they established a topical outline for each instructional area.

The group charged with obtaining information about numerical control machine tools and peripheral equipment found that there was a twelve- to eighteen-month lead time for this type of equipment. Therefore, much of the tooling and other peripheral equipment would be difficult to obtain. However, in their contacts with manufacturers, they were able to get tentative commitmemts for obtaining the use of several machine tools during the time of the seminar. The commitments had to be finalized by the first of May.

Final approval of the seminar was not obtained until the end of April. This meant that there were only six weeks to develop the full program, obtain the necessary equipment and teaching material, and, even worse, only four weeks to contact possible participants, select those that fit the criteria, and notify them of the choices made.

It was decided that the best way to contact possible participants was through the various state vocational directors. A brochure was developed as well as an application form. (See Appendix A-2.) These were then printed and mailed to the state directors for distribution. These forms had to be completed, approved by the various directors, and returned in only a few weeks' time. The applicants were to be notified of their selection or rejection by the end of May.

Stout State University, after careful examination of the proposal, agreed to grant eight semester credits to those who completed the program and had made prior registration with the University for such credit. This was done under their off-campus program.

The faculty for the program was obtained from the school staff. They were presented with the material developed by the committee that had worked on the proposal. Instructors were asked to develop the materials to be used by them in the seminar. This involved considerable work in relating available material to numerical control technology. In many areas, original material had to be developed. Much of the material to be developed depended upon the machine tools that would be available for student use during the seminar. Some of the material could not be developed until the instructors had some training on a particular machine. The manufacturers who contracted with the school in the use of their machines made available many informational and instructional manuals gratis or for a nominal fee. Some of the manufacturers made drawings available that would conveniently lend themselves to conversion to numerical control drawings in a classroom situation. Castings were made in the school foundry for parts that were to be machined from programs written by the students. The school was able to obtain four machines to be used during the seminar: a Pratt and Whitney Model B; a Sundstrand Rockmill; a Moog Hydra-Point; and a Bridgeport Mill retrofitted with Slo-Syn controls. Kearney and Trecker Corporation made available its training center and a Model EA for use by the participants. The staff was very pleased that this much equipment was available considering the short time available for procuring it. However, because of this lack of lead time, only two Flexowriters were obtainable. For the number of expected participants, it was felt that at least five of these machines would be needed. This necessitated the hiring of a girl to punch the students' tapes.

At this time, final arrangements for housing were made with the YMCA and two nearby schools that have dormitories. The host school serves, basically, the City of Milwaukee and therefore only a small percentage of its students do not live within commuting distance. Therefore, the school has no dormitories of its own.

The machine technology instructors had to be trained on the various machine tools used during the seminar. This necessitated sending them to company schools or waiting until the machines were set up in the school and having company representatives come in to conduct the training sessions. Either way, there was a delay in developing the course materials to be used in conjunction with each machine until after the instructors had learned the particular machine programming, set-up, and operation. (During the six weeks prior to the seminar, the instructors were teaching full time. This meant that all of this training was taken on their own time. They were compensated for a part of it.)

The class schedules were drawn up, dividing the group into two sections. Because some of the related work had to be completed before the students could begin working on the machines and also because of the different lengths in hours of the courses, a separate schedule had to be made out for each week. Arrangements were made for field trips to various numerical control machine tool manufacturing plants and research centers in the area. Resource personnel were contacted and arrangements were made for them to present talks to the participants. (See Appendix A-4 and 5.)

Final arrangements were made for the machine tools to be delivered and set up in the school. The automobile shop was used because of the large amount of floor space available.

The first day of the program was taken up with registration, orientation, and special problems encountered by some. From there on, the class program was followed. At the end of the seminar, a questionnaire was given to the participants asking for their appraisal of the program. One year later, there was a follow-up questionnaire sent to the participants and a questionnaire sent to state directors. These are discussed in the following sections.

RESULTS

Project No. 6-2332, "An Eight-Week Seminar in an Introduction to Numerical Control on Two- and Three-Axis Machine Tools for Vocational and Technical Machine Tool Instructors," was conducted from June 20 through August 12, 1966. Thirty-three participants attended and completed the program as described in the contract. Nearly one half of the group took advantage of the offer of Stout State University to grant either graduate or undergraduate credit to those who qualified. Success of the seminar was measured with the use of three questionnaires and with reports from the faculty involved. All indicated the seminar as successful. Minor adjustments would be recommended for future seminars of this type. This seminar served to substantiate the validity of the rapidly developing numerical control technology in the vocational and technical school. Numerical control technology has now become an accepted area of training in many post-high-school training institutions, the number of numerical control training programs in operation in the sixteen states involved being 16 in 1965-66 and anticipated at 75 in 1968-69. Certainly this seminar was instrumental in making this rapid development possible.

At the same time that these changes were taking place within education, an interest was also developing within the numerical control industry to allow schools a place in numerical control training. Numerous numerical control manufacturers have cooperated in making available to schools the equipment that is needed to develop a numerical control training program. The industrial contacts made before and during this seminar were instrumental in making the numerical control industry aware of the necessary role that schools must play in future numerical control training. It is impossible to fully measure the impact of this seminar, but assuredly numerical control has become a real fact in vocational and technical schools.

DISCUSSION

The seminar was conducted as scheduled with thirty-three teachers in attendance. Seventeen states were represented, as follows: Michigan, 5; Minnesota, 5; Wisconsin, 3; two each from Idaho, Illinois, Kansas, Massachusetts, Washington, and West Virginia; and one each from Arizona, Colorado, Connecticut, Georgia, New Mexico, New York, Oregon, and South Dakota. Nineteen of these men indicated they taught in vocational schools; six in junior colleges; and two in each of the following: comprehensive high school, college, technical school, and community college.

The level of academic training of the participants is indicated by the highest degree earned, as follows: M.A. or M.S., six; B.S. or B.A., fifteen; A.A.S., one; diploma, two; and no degree, nine. Those who had not earned a degree each had a considerable number of college credits accumulated.

Twenty-three of the participants identified themselves as machine shop instructors, two as tool and die instructors, two as vocational instructors, one as a welding instructor, two as mechanical technology instructors, one as a professor of general metals, and two as associate professors. It is notable that the range of service as a teacher was from one to twenty-nine years, with an average of nine years and a mean of six years.

Industrial experience of the group ranged from no experience to twenty-three years of industrial experience, with an average of almost ten years and a mean of ten years. Seventeen of these participants had served an apprenticeship, fourteen indicated no apprenticeship, and two failed to comment.

Twenty-five participants indicated no previous training in numerical control other than reading and films. The NC training that the remaining eight had had was extremely varied. One had been engaged in making economic studies of numerical control machines, two had attended short seminars sponsored by the ASTME, two indicated brief training by Pratt and Whitney, two actually planned and worked with numerical control in a shop for less than a year's time, and one had attended a 120-hour course on numerical control conducted by Lockheed-Georgia Company.

The varied backgrounds, especially in the mathematics and science areas, was without a doubt responsible for attitudes that developed in regard to sections of the program dealing specifically with mathematics, electronics, and hydraulics. Those participants with limited backgrounds in these areas found it

difficult to maintain the pace of the class. Instructors in these areas did a fine job of building backgrounds in these areas to make a total understanding of numerical control possible for all participants.

The seminar progressed smoothly and the day-to-day problems were solved as they appeared. A rigorous pace was maintained, with classes being held six hours per day and extra machine time being scheduled for late afternoons as the program progressed. Two evening sessions were held each week to bring in experts from the field. The seminar concluded with the thirty-three participants having been exposed to eight weeks of concentrated effort directed toward understanding and using point-to-point numerical control machine tools.

In an effort to understand what had been accomplished, a questionnaire was given on the final day of the seminar as the first means of interpreting results. The instrument used was composed of nine questions, each of which could be answered in a sentence or a paragraph. (See Appendix B-1) This is a difficult form to interpret but it did allow the participants to "let off steam" and to give a picture of the good and bad aspects of the just-completed seminar.

The first question was, "What part of the seminar did you profit from most?" In answering this question an extreme variety of answers was received. Many were fascinated by the laboratory experience, others grateful for the plant tours, the mathematics review, the electronics review, the association with other teachers, the programming, and the teaching methods used. The answers varied, but throughout there was an indication of "here is a field of learning to conquer" and "I'm on the trail of something big and this is just the beginning."

The second question was, "What part of the seminar did you profit from least?" The answer to this question, of course, brought out some of the negative aspects of the seminar. Many of the "problems" mentioned are those that occur regularly in machine- and shop-oriented programs, such as repetition of subjects or material, especially by resource people. Instructors also may have repeated one another due to this "first-time" aspect of the program. Some objected to the electronics and hydraulics as not necessary. Technology seemed unnecessary to some. This question brought to light the variety of backgrounds of the participants by their reactions to the more technical areas of the seminar curriculum.

The third question was, "Was this seminar well organized?" Here the answers indicated "yes" and also "no." Some thought more machine time should have been given with fewer men assigned to a particular machine at a time. Some complained about communication, saying that they should have been informed in writing, in advance, of all seminar activities. Others recognized the seminar as being well organized, with good course content, and also as an introduction to a new field which needs further pursuit on an individual basis.

Question four was, "Did you like the way the material was presented?" Comments ranged from "no" to "yes." Some indicated that the lectures were too long; however, for the most part, answers indicated no unusual problems here. One participant wrote "Electronics material was excellent."

Question five asked, "Did you consider some of the material a "waste of time?" Answers here were mostly "no." The "yes" answers referred to some of the machine technology, drawing, and electronics. These, very likely, reflected the background of the participant, indicating that he may have been familiar with some of the material or that he may have been completely lost.

Question six asked, "Is the length of each session too long or too short or just right?" Eighteen answers indicated "just right," while the remainder thought the session too long or too short. Understandably, a summer seminar must present large amounts of material in a short time.

Question seven asked, "Is the length of the seminar proper?" Most indicated the length of the seminar was just right.

Question eight asked, "If you were running the seminar, what would you do to make it better?" Comments on this question seemed to revolve around trying to get more experience on the numerical control machines.

Question nine asked, "What would you like to have presented at future conferences?" Answers to this question included: contouring, computer-assisted numerical control, and numerical control maintenance, or, as one participant answered, "A study of computers and computer languages should most certainly follow the overall fine seminar I attended this summer."

As indicated previously, answers to this instrument were given on the last day of the seminar after eight strenuous weeks of training, and should be interpreted in that manner. These comments have been thoroughly examined by the instructors and administra-

tors of this program, and reflections of these comments are visible in the host school's numerical control program.

In September of 1967, a second and final evaluation was mailed to the participants of the seminar. (See Appendix B-4.) Of the thirty-three questionnaires mailed, twenty-six were returned completed and two were returned as undeliverable. Part A questioned the participant's professional preparation by asking, "What is the highest degree that you hold?" The answer indicated one Associate degree, eight Bachelor's degrees, four Master's degrees, two with less than twenty college credits, and eleven with twenty to eighty college credits.

Part B questioned the participant's trade preparation with the question, "How did you acquire your trade background?" Eight indicated informal self-training on the job; two, company training programs; six, informal apprenticeship; seven, formal apprenticeship; ten, vocational training programs; four, technical training programs; three, industrial arts degree; and two, "other," which included engineering training, military service, or other trade experience.

Part C questioned the participant's teaching experience with the question, "What is your teaching assignment primarily?" Answers here indicated three shop, ten lecture-shop, eight lecture-laboratory, three lecture, one supervisor, and one related math and drawing instructor.

Part D asks about school use of numerical control with the question, "What was the first year numerical control was taught in your school?" Two said in 1963; one, in 1964; eight, in 1966; and four, in 1967. To the question, "Which phase of numerical control does your current program emphasize?", eight answered machine operator; fifteen, programming; and two, maintenance.

In answer to a question asking for titles of numerical control courses taught, a wide variety of titles was given, indicating either laboratory or theory work with several special courses aimed at mechanical technicians.

Another question asked, "What courses do you expect to add?" Here the answer seemed to be advanced or special courses. Such fields as numerical control for management, continuous path numerical control, numerical control with EDM, and numerical control in industrial production are examples of courses in the planning stage.

The next question asked for a list of textbooks used in numerical control courses. This list was rather brief but included the following: Porter, Lascoe and Nelson, Machine Shop; Childs, An Introduction to Numerical Control; Modern Machine Shop; Let's Discuss Numerical Control; ASTME, Program Learning Series, McGraw Hill, Numerical Control in Manufacturing.

Part two asks for numerical control equipment presently used in the participant's school. The following machine tools and tape punches were mentioned: Moog 2-axis mill; Pratt and Whitney Model B; Rock Mill Model 400; Gorton 3-axis mill; Slo-Syn Bridgeport; Milwaukeematic Model EA; Cintimatic Machining Center; Hillyermatic; Giddings and Lewis Numerimite; Sheffield Measuring Machine; Ollivette 3-axis measuring machine; Friden Flexowriter; Tapestor tape punch; and Navcor tape punch.

Additional equipment expected by June, 1968, included Compudyne 3-axis vertical mill; Gorton 3-axis mill; Gorton Continuous-Path Mill; Slo-Syn on a new Bridgeport mill; Pratt and Whitney Model B; and a Moog mill.

The question, "Which numerical control machine tools are best adapted to school use?", brought answers of Pratt and Whitney, Moog, and Gorton, and also answers indicating this was dependent upon the school's program. With regard to the question, "How much money has your school invested in numerical control?", the answers ranged from nothing to $160,000, most schools having spent less than $40,000 at this time.

Section E raises the question, "How would you evaluate the numerical control seminar held at the Milwaukee Vocational Technical and Adult Schools?" Seventeen answered above average, eight answered average, and one indicated below average. This clearly indicates that one year after the seminar had closed at least half of the individual participants believed this was a better-than-average seminar. When asked if they would personally recommend attendance at a similar numerical control seminar at the Milwaukee Vocational Technical and Adult Schools to a fellow machine shop instructor, the answer was 26 yes. When asked, "What is your current involvement in your school's numerical control curriculum?", the respondents indicated that fourteen are teaching, seven will be teaching, and twelve are responsible for curriculum, while three indicated "other."

The question asking, "What is your current reference for answers to questions concerning numerical control?" brought a variety of answers from texts to industry, but no real logical place to procure ready, up-to-date information.

The last question asked was, "How much use of numerical control machine tools is made by industry in your geographic area (within 50 miles)?" The answers came back to us as five "extensive," thirteen "some," two "little," four "none," and three "uncertain."

It was most gratifying to note the answers and comments on this first numerical control program. Without a doubt, many of the people who attended this conference are dedicated teachers who will use and disseminate the knowledge and the skills of numerical control to their students and fellow teachers.

A brief questionnaire was sent to the state directors involved. (See Appendix B-9) Seventeen letters were sent and sixteen returned. One letter was misdirected and remained unanswered. Answers to the first question indicated that four states offered sixteen programs in the 1965-66 school year; while ten indicated they offered forty-seven programs in the 1966-67 school year.

In response to the second question, thirteen indicated they expected to be operating fifty-eight programs in the 1967-68 school year; and that they expected to have seventy-five during the 1968-69 school year.

The third item was, "Please indicate the reasons you are not offering or have not offered a machine shop numerical control program." To this, one answered "no apparent demand," three indicated that no qualified teachers were available, and four indicated that the equipment was too costly.

The next question asked, "Was the 1966 Summer Numerical Control Seminar at the Milwaukee Vocational Technical and Adult Schools of help to your state in establishing a numerical control program?" To this question fifteen said yes, one said no. To the question, "Would your state participate if another national numerical control seminar was held?", fifteen said yes and one said no.

The final questions asked for suggestions as to future numerical control seminars. Comment was not large on this question but suggestions included: (1) more lead time, (2) teach introduction to computer programming also, (3) teach less electronics, (4) include more numerical control in the design area, (5) hold workshops in other large metropolitan areas and other states, (6) write a program for local use, (7) get more suitable housing for participants, (8) spend more time operating numerical control equipment, (9) an excellent seminar, (10) make annual arrangements for this type of program.

Indications as judged from the foregoing information are that the seminar was well accepted, the quality of instruction given was good, the results were as stated in the objectives, and consideration should be given to further seminars of this type.

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

The discussion section of this report presents a picture of the developing numerical control technology. As indicated by the sixteen state directors, in the school year 1965-66 four states had sixteen numerical control programs operating and twelve states had no programs; in the school year 1967-68 thirteen states had fifty-eight programs in operation while only three had no programs; and for next year even more programs are anticipated. Considering the high cost of a program, this indeed is truly a remarkable expansion. No doubt many of the states not represented in this seminar are also in the midst of developing numerical control programs. Certainly it can be concluded from this that the Summer of 1966 was ideal for developing and offering an eight-week seminar on numerical control.

The question then arises as to the influence the seminar had in the development of the expanding numerical control technology. The answer comes from the twenty-six who answered the questionnaire. Of this group, fourteen indicated they are teaching numerical control, seven more expect to be teaching numerical control, two are supervisors, and three indicated other responsibilities. Of this group twelve indicated responsibility for numerical control curriculums. This would seem to indicate that one out of every four teachers actually teaching numerical control in the states represented was in attendance at the Milwaukee Vocational Technical and Adult Schools seminar. This seminar must have had considerable effect in the development of these numerical control programs. Seventeen out of twenty-six participants indicated that this was an above-average seminar and that all twenty-six would recommend attendance at a similar seminar to a fellow instructor. This indicates that the objective of assisting the machine shop instructor in developing skills and knowledge for teaching the basics of programming and operation of numerically controlled machine tools was achieved.

It also seems apparent that numerical control training is post-high-school training, is vocationally oriented, and should remain in the post-high-school technical school and be offered as technical training for those seeking entry into the field of numerical control machining. As the previous figures indicate a phenomenal growth pattern, it is consistent and imperative that further numerical control teacher training seminars be developed and held at the earliest possible time. To this end, the State of Wisconsin through the Board of Vocational Technical and Adult Education cooperating with the Milwaukee Vocational Technical and Adult Schools offered

four weeks of numerical control training to Wisconsin vocational and technical instructors during the summer of 1967. The real problem, however, is a national one and the solution needs to be made at that level.

Recommendations by the Seminar Faculty

The faculty of the seminar met a number of times after the completion of the program and discussed some of the problems encountered. All felt that the short lead time had hurt the program. They felt that they were not as well prepared as they would like to have been and had they had more time to prepare, many of the problems that arose in the shops could have been foreseen and thus avoided. Some of the recommendations of the instructors are:

1. The brochure that goes out to describe the seminar should clearly state the background and the purpose of the seminar. Too many of the participants thought that the seminar was set up to teach only machine operation. They did not understand the broader concepts of the seminar.

2. The evening seminar used should be for laboratory sessions and for speakers. The topics of the speakers should be coordinated with what the students are doing during the day. There was too much overlapping by the speakers and no seemingly organized utilization of the talks given by these resource people. Again, the lack of time in obtaining these speakers played a big role in the organizing of these talks. More lead time is necessary to work with the speakers in order to coordinate the class work with the evening talks.

3. The program should remain at eight weeks in length. This amount of time seems very necessary.

The rest of the suggestions covered revamping the areas of instruction, the course content, and the teaching order of the various areas, in order to better coordinate the classroom and shop work. A copy of the revised program as agreed upon by the faculty is included in Appendix C-1. It should be noted that an introduction to computer-assisted programming has been added.

SUMMARY

The problem presented to this seminar was to assist the machine shop instructor in developing skills and knowledge essential for teaching the basics of programming and operation of numerically controlled machine tools in vocational and techincal schools, limiting the training to two- and three-axis (without computer assist) machine tools. This problem was solved by organizing thirty-three instructors from seventeen states into classes designed to teach the specifics called for in the stated problem. This was accomplished in eight weeks using the regular and special facilities provided by the Milwaukee Vocational Technical and Adult Schools. In addition, numerous resource persons from industry and several in-plant training sessions contributed greatly to the success of this seminar.

Results are apparent from the answers to questionnaires sent to participants and state directors. Participants are now teaching in many numerical control programs, and both participants and state directors have indicated confidence in the seminar. All evidence would seem to indicate that further seminars of this type and also an advanced seminar using computer-assist numerical control should be offered as soon as financially feasible.

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Proposal Committee

The following men from the Milwaukee Vocational Technical and Adult Schools served as a Committee to prepare a proposal for a Numerical Control Seminar:

Mr. Arthur P. Carlson, Chairman
Mr. John J. Makowski, Co-Chairman
Mr. Edwin J. Taibl, Co-Chairman

Mr. Milton E. Boldt, Program Planning
Mr. George A. Krall, Program Planning
Mr. Harry E. Pokorny, Program Planning
Mr. Thomas C. Turcin, Program Planning

Mr. Fred C. Mulcahy, Publicity

Mr. Arthur P. Carlson is a Graduate Engineer and Educator with the position of Faculty Counselor in the school.

Mr. John J. Makowski is a Graduate Engineer with the position of Assistant to the Director and Chairman of the Evening Schools.

Mr. Edwin J. Taibl is a Faculty Counselor in the areas of electrical, fluid power, and metallurgical technologies.

Mr. Milton E. Boldt is an Evening School Faculty Counselor in the areas of machine shop and welding.

Mr. George A. Krall is an instructor in the area of machine shop technology.

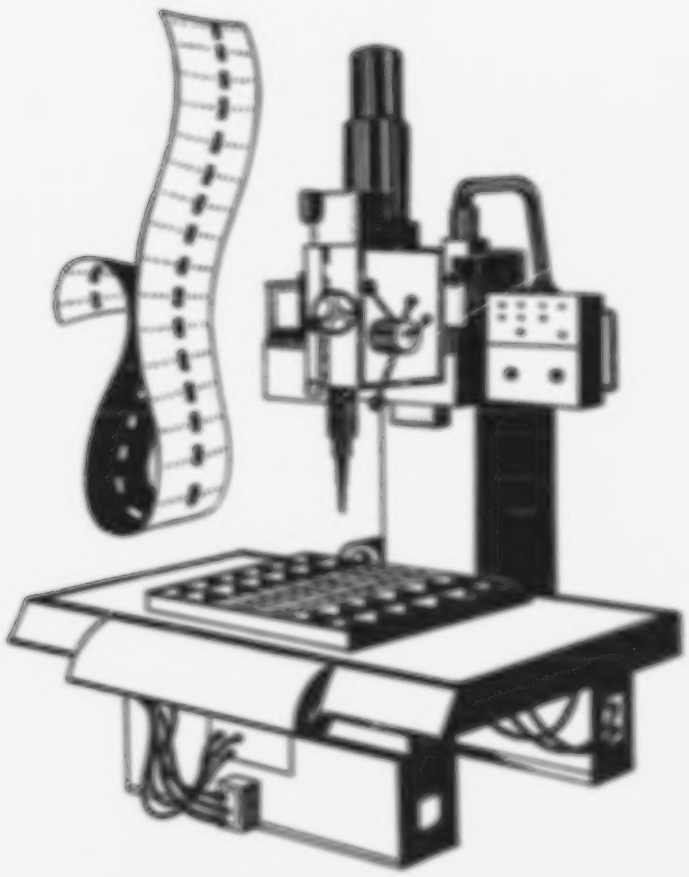
Mr. Harry E. Pokorny is an instructor in the area of electronic and electrical technology.

Mr. Thomas Turcin is a local Manpower Development and Training Act Supervisor with a related manufacturing processes background.

Mr. Fred C. Mulcahy is a Special Service Counselor serving in a public relations capacity.

1966 SUMMER INSTITUTE

NUMERICAL CONTROL TEACHER EDUCATION



MILWAUKEE VOCATIONAL TECHNICAL
AND ADULT SCHOOLS
MILWAUKEE, WISCONSIN

JUNE 20 TO AUGUST 12

This institute represents the cooperative effort of the Wisconsin Board of Vocational and Adult Education and the U.S. Office of Education.

OBJECTIVE

The purpose of the institute is to assist the Machine Shop instructor in developing skills and knowledge essential for teaching the basics of programming and operation of numerically controlled machine tools in vocational and technical schools. This institute will be limited to the use of two- and three-axis (without computer assist) machine tools.

ELIGIBILITY

The criteria for selection of applicants will include the following:

1. Participants in the institute will be selected from forty areas of need on a national basis.
2. A four-year degree or equivalent in an applicable area of machine trades learning.
3. At least three years of trade experience or equivalent on the journeyman level in a field involving the use of machine tools.
4. Currently employed or under contract as an instructor in the field of machine tool operation or a related area of instruction in which a current knowledge of numerical control would be desirable.
5. Recommended by State Director of Vocational Education of Applicant's own state.

COURSE CONTENT

This program is designed to meet the needs of instructors with machine tool trades background, who need to know numerically controlled machine tool operations.

Courses begin with reviews and continue to the level required to understand and operate two- and three-axis (without computer assist) machine tools.

1. Mathematics Review — 24 hours

   Objective: Review of mathematics as applied to numerical control specifics.

   a. Algebra
   b. Geometry
   c. Trigonometry
   d. Applied analytical geometry

2. Hydraulics and Pneumatics — 16 hours

   Objective: Application of basic fluid power principles and devices to numerical control.

   a. Fluid power principles
   b. Diagram interpretation
   c. Circuitry
   d. Control systems

3. Electronics — 48 hours

   Objective: Application of basic electronic principles and devices to numerical control.

   a. Refresher in AC and DC fundamentals
   b. Electronics principles — tubes, diodes, transistors
   c. Elementary pulse circuitry
   d. Electronic switching circuits, using diodes, relays, tubes, and transistors for control
   e. Feedback (servo loops)
   f. Relays and switches

4. Drawing Interpretation and Preparation — 24 hours

   Objective: Conversion of standard drawings to numerical control standards.

   a. Standard drawing specifications
   b. Numerical control drawing techniques
   c. Coordinate determination

5. Machine Technologies and Numerical Control Procedures — 24 hours

   Objective: Adapting job requirements to machine capabilities.

   a. Speeds and feeds
   b. Holding devices
   c. Toolholding devices
   d. Tooling
   e. Sequences of operations
   f. Nomenclature

6. Part Programming — 84 hours

   Objective: Programming the job from blueprint to tape.

   a. Coding of print
   b. Operations sequence
   c. Coordinate determination
   d. Process planning
   e. Tape generating
   f. Tape prove-out

7. Part Processing — 24 hours

   Objective: Actual operation of two-axis numerical control machine tools.

   a. Machine operation
   b. Machine trouble shooting
   c. Machine preventive maintenance

ACADEMIC CREDIT

Successful completion of the institute may entitle the participant to degree or non-degree credit, depending upon the status of the participant. Participants desiring college credit will need to request specific information from the Director of the Institute prior to the opening of the institute.

ALLOWANCES

An allowance for subsistence of $75 a week for the participant plus $10 a week for each dependent will be given for the seminar. Dependents must be in residence in Milwaukee with the participant. In addition, a travel allowance of eight cents a mile for a round trip will be paid from his home to Milwaukee.

TUITION, FEES, AND TEXTS

Participants will be furnished with all materials required, and no tuition or fees will be charged. Individuals desiring college credit may be required to pay a fee.

HOUSING

Adequate housing is available within walking distance of the institute. Reservations should be made prior to arrival in Milwaukee. Further information should be obtained through the Director of the Institute.

ADMISSION PROCEDURES

Application forms may be obtained from the applicant's State Director of Vocational Education, or the Director of the Institute. Applications will be processed as received. Forms should be completed in duplicate, signed by the applicant and by the State Director of Vocational Education, and forwarded to the Director of the Institute.

1966 Summer Institute
Numerical Control Teacher Education
Milwaukee Vocational Technical and Adult Schools
1015 North Sixth Street
Milwaukee, Wisconsin 53203

MILWAUKEE VOCATIONAL TECHNICAL AND ADULT SCHOOLS
1015 North Sixth Street
Milwaukee, Wisconsin 53203
Telephone 414 - 271-4341

ADDRESS COMMUNICATIONS TO DIRECTOR NUMERICAL CONTROL SEMINAR

APPLICATION FOR PARTICIPATION IN NUMERICAL CONTROL TEACHER EDUCATION SEMINAR

THIS SEMINAR REPRESENTS THE COOPERATIVE EFFORT OF THIS INSTITUTION, THE WISCONSIN STATE BOARD OF VOCATIONAL, TECHNICAL AND ADULT EDUCATION, AND THE U. S. OFFICE OF EDUCATION.

This completed application should be sent in duplicate to the Director of the Institute. Applications will be processed as received. Deadline for filing applications is May , 1966.

Type or write a complete answer to each item, using "None" where appropriate. Use an extra sheet, if necessary.

1. Name
   Mr. Mrs. Miss _____ 2. _____
   (Encircle one) Last First Middle Social Security Number

3. Name of school in which you teach _____
   School address _____
   Number and Street City Zone State

   Your position _____ Type of School: _____ College _____ Junior College
   _____ Technical _____ Vocational
   _____ Other

4. Name and location of school in which you expect to teach numerical control
   _____

5. Residential address _____
   Number and Street City Zone State

6. Mailing address you wish used: _____ School (Item 3) _____ Residence (Item 5)

7. Single _____ Married _____ Dependent Children _____ Ages _____

8. Date of birth _____ 8a. Citizen of United States? ___Yes ___No
   Month Day Year

9. Employment Record. List only experience related to machine tool operation or area of work that is related to numerical control.

Dates	Total Months Worked	Full-Time	Part-Time	Employer	Nature of Activity

(over)

10. Employment Record. List only teaching or work related to teaching.

Years From To	School	City and State	Nature of Activity

11. Teaching certificate held: Permanent or full accredited_____Vocational _____

No certificate_____Temporary or emergency_____Other_____

12. Teaching Experience:

Subject	From To	Level (college, high school, adult, etc.)

13. Have you ever served an apprenticeship? _____

14. Education beyond high school:

Institution	From To	Degree	Major	Minor

15. What training have you had in the area of numerical control?

16. Indicate your reasons for wanting this numerical control training, with emphasis on your plans for making use of this training.

SIGNATURES:

_____ _____
Applicant Date

Approved: _____ _____
State Director of Vocational Education Date

Approved: _____ _____
Institute Director Date

Seminar Speakers

The following men each presented a talk to the Numerical Control Seminar:

Mr. Marshall H. Sageser, Jr.,
Factory Manager
Waukesha Bearings Corporation

Mr. Herbert Gensrick, Industrial
Engineer
Allis Chalmers

Mr. James Morgan, Industrial
Engineer
Galland Henning Nopak

Mr. E. Kirkham, Associate Director of
Technical Engineering
Kearney & Trecker Corporation
Past President - N.C. Society

Mr. Robert Bachmann, Training Director
Kearney & Trecker Corporation

Mr. Charles Overeem, Programmer
Marnischfeger Corporation

Mr. Thomas Jenner, District Manager
Pratt & Whitney Corporation

Mr. Alum C. Thomas, Assistant
Supervisor
Trade & Technical Education
Madison Vocational, Technical and
Adult Schools

Mr. A. Marcone, Regional Numerical
Control Representative
International Business Machines

Mr. Robert W. Reinhardt, Regional
Manager
Burgmaster Machine Corporation

Field Trips

In-plant training sessions were held for the Seminar by the following plants:

Sunstrand Corporation - Rockford, Illinois

Allis Chalmers Manufacturing Company - Milwaukee, Wisconsin

Illinois Institute of Technology Research Institute - Chicago, Illinois

Square D Company - Milwaukee, Wisconsin

Giddings and Lewis Machine Tool Company - Fond du lac, Wisconsin

Kearney & Trecker Corporation - Milwaukee, Wisconsin

Milwaukee Vocational Technical and Adult Schools

Numerical Control Seminar

ANALYSIS SHEET

WHAT WOULD YOU HAVE DONE?
WE WANT CRITICISM!!!!!!!!!

Don't sign your name. We don't know your handwriting. Another conference member will collect these criticism sheets, so be honest with your criticism.

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1. What part of the Seminar did you profit from most?
   Why?

2. What part of the Seminar did you profit from least?
   Why?

3. Was this Seminar well-organized?
   How could the organization be improved?

Numerical Control Seminar
Analysis Sheet

4. Did you like the way the material was presented?
   How could we do better?

5. Did you consider some of the material "A waste of time?"
   What material was it?

6. Is the length of each session - too long? _____ too short? _____
   just right? _____ Why?

7. Is the length of the Seminar - too long? _____ too short? _____
   just right? _____ Why?

Numerical Control Seminar
Analysis Sheet

8. If you were running this Seminar, what would you do to make it better?

9. What would you like to have presented at future conferences?

Milwaukee Vocational Technical and Adult Schools

1015 North Sixth Street

Milwaukee, Wisconsin 53203

Numerical Control Seminar

Summer - 1966

Final Evaluation for Participants

Please answer the following questions:

A. Participant's Professional Preparation.

1. What is the highest degree or diploma that you hold?

_____ High School

_____ Associate Degree

_____ Bachelor's Degree

_____ Master's Degree

_____ Doctor's Degree

_____ 0 to 20 college credits

_____ 20 to 40 college credits

_____ 40 to 80 college credits

B. Participant's Trade Preparation.

1. How did you acquire your trade background?

_____ Informal self trained on job

_____ Company training program (6 mo. or more)

_____ Informal apprenticeship

_____ Formal indentured apprenticeship

_____ Vocational training program

_____ Technical training program

_____ Industrial arts degree

_____ Other (explain) _____

2. What is your trade experience?

_____ Number of years of trade experience

_____ Date of most recent employment as a tradesman; list specific job titles you have held within your trade

_____

_____

_____ If you were a supervisor, how many employees did you supervise?

C. Participant's Teaching Experience

1. How is your present teaching assignment classified?

_____ Junior High Teacher

_____ Senior High Teacher

_____ Vocational-Technical School Teacher

_____ Junior College Teacher

_____ College Teacher

2. _____ How many years have you taught as a full-time teacher?

3. What is your teaching assignment primarily?

_____ Shop

_____ Lecture-Shop

_____ Laboratory

_____ Lecture-Laboratory

_____ Lecture

_____ Supervisor

_____ Other _____

2. Course use of NC

a. Courses taught.

_____How many NC/CNC courses do you teach at your school.

_____Which phases of NC does your current program emphasize? (a) Machine Operator (b) Programming (c) Maintenance

How effective would you rate your school courses in NC.

_____

_____

_____

How many courses you expect to add.

_____

_____

_____

List textbooks you currently use for NC courses.

_____

_____

_____

2. Equipment used

List NC machine tools your school currently has.

_____

_____

_____

What additional NC equipment you expect to add by June '68.

_____

_____

_____

What NC machine tools do your feel are best adapted to school use?

_____

Approximately how much money has your school invested in NC equipment

_____

2. NC Seminar at Milwaukee Institute of Technology

1. How would you evaluate the NC Seminar held at the Milwaukee Institute of Technology?

   Above average _____ Average _____ Below average _____

2. Would you personally recommend attendance at a similar NC Seminar at the Milwaukee Institute of Technology to a fellow machine shop instructor?

   _____Yes _____No

3. What is your current involvement in your school's NC curricula?

   _____ Teaching

   _____ Will Be teaching

   _____ Supervisor

   _____ Responsible for curriculum

   _____ Other _____

4. What is your current reference for answers to questions concerning NC?

   _____

5. How much use of NC machine tools is made by industry in your geographical area (within 50 miles)?

extensive____ some____ little_____ none____

uncertain____

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Numerical Control Seminar

Summer - 1966

Final Evaluation for State Directors

1. Were any Machine Shop Numerical Control Programs in operation in your state in the school year

1965-66	_____Yes	_____No	_____How Many
1966-67	_____Yes	_____No	_____How Many

2. Do you expect to be operating vocational or technical Machine Shop Numerical Control Programs in your state in the school year

1967-68	_____Yes	_____No	_____How Many
1968-69	_____Yes	_____No	_____How Many

3. Please indicate the reasons you are not or have not offered a Machine Shop Numerical Control Program.

_____ 1. No apparent demand
_____ 2. No qualified teachers available
_____ 3. Equipment too costly
_____ 4. Other (explain)_____

4. Was the 1966 Summer Numerical Control Seminar at the Milwaukee Institute of Technology help to your state in establishing, expanding, or continuing a NC program?

_____Yes _____No

5. Would your state participate if another national NC Seminar on NC were held?

_____Yes _____No

6. What suggestions can you make in regard to future NC Seminars?

Suggested Curriculum

A. Mathematics - 24 hours

Objective: Survey of mathematics as applied to numerical control specifics

1. Algebra
2. Geometry
3. Trigonometry
4. Applied analytical geometry
5. Boolean algebra

B. Hydraulics and Pneumatics - 26 hours

Objective: Application of basic fluid power principles and components to numerical control

1. Fluid power principles
2. Principles of construction and operation of components
3. Diagrams - interpretation
4. Circuits
5. Control systems

C. Electronics - 48 hours

Objective: Application of basic electronic principles and devices to numerical control

1. Refresher in AC and DC fundamentals
2. Electronic principles--tubes, diodes, transistors
3. Elementary pulse circuitry
4. Electronic switching circuits, using diodes, relays, tubes, transistors for control
5. Feedback (Servo Loops)

D. Numerical Control Procedures - 24 hours

Objective: To acquaint the student with the historical development of numerical control and its applications to the machine tool industry

1. What is numerical control?
2. The numerical control process
3. Drafting techniques
4. Input medium
5. Programming
6. Machine component technology
7. Tool path determination
8. Machine cutting technology

E. Part Programming - 72 hours

Objective: Programming the job from blueprint to tape

1. Coding of print
2. Operations sequence
3. Coordinate determination
4. Process planning
5. Tape generating
6. Tape prove-out

F. Part Processing - 38 hours

Objective: Operation of two- and three-axis numerical control machine tools

1. Introduction to machine operation
2. Machine operation
3. Machine troubleshooting
4. Machine preventive maintenance

G. Computer Assisted Programming - 18 hours

1. When to use computer assisted programming
2. The purpose of computer languages
3. An aid to point-to-point programming
4. An aid to continuous path programming

H. Manufacturers' In-Plant Instruction - 30 hours

Objective: Personal contact with builders and users of numerical control, and observation and individual student evaluation of numerical control in operation

1. Builders of numerical control machines and control units:

   a. Milling and drilling two-axis
   b. Machining center five-axis

2. Users of numerical control machines:

   a. Small plant application
   b. Large plant application

3. Computer assisted programming